

# **Development of Highly Durable and Reactive Regenerable Magnesium-Based Sorbents for CO<sub>2</sub> Separation in Coal Gasification Processes**

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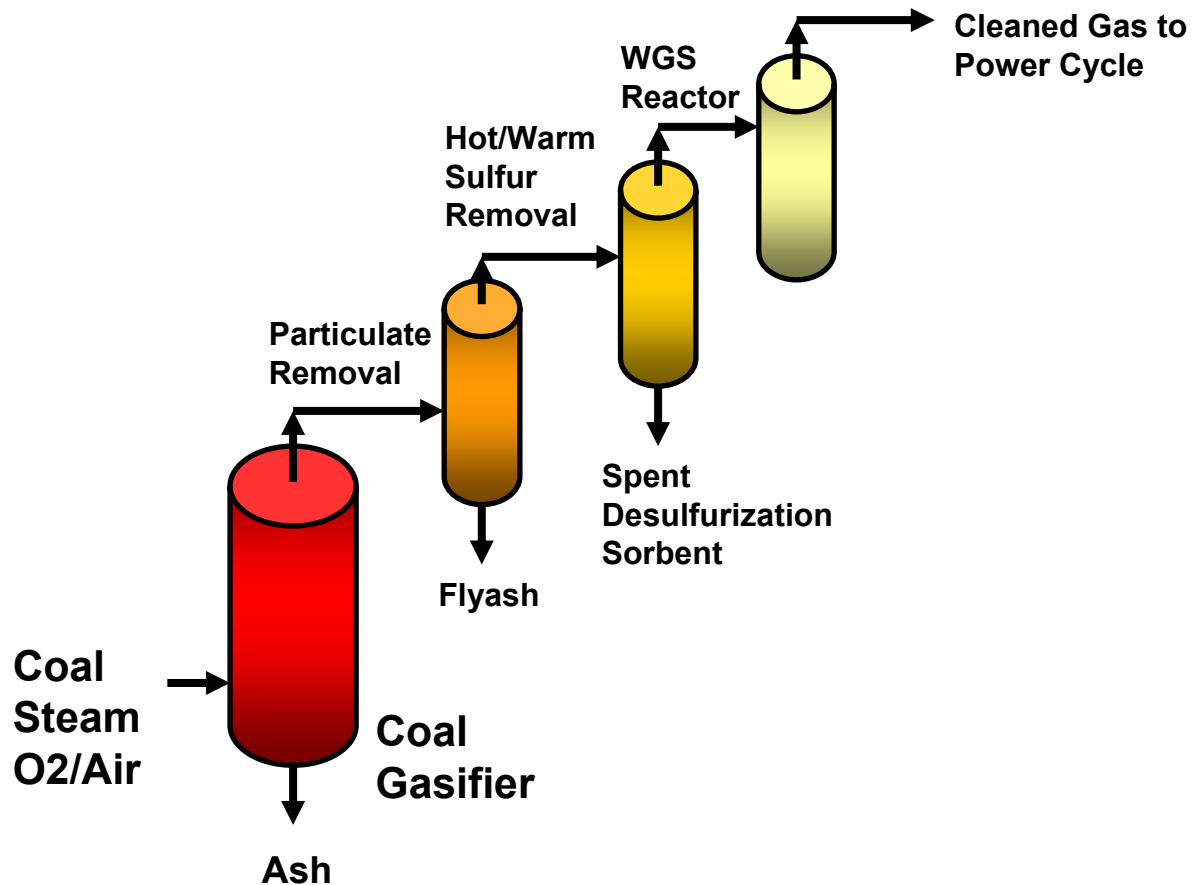
**Annual UCR Contractors' Review Meeting  
Pittsburgh, PA  
June 10, 2004**



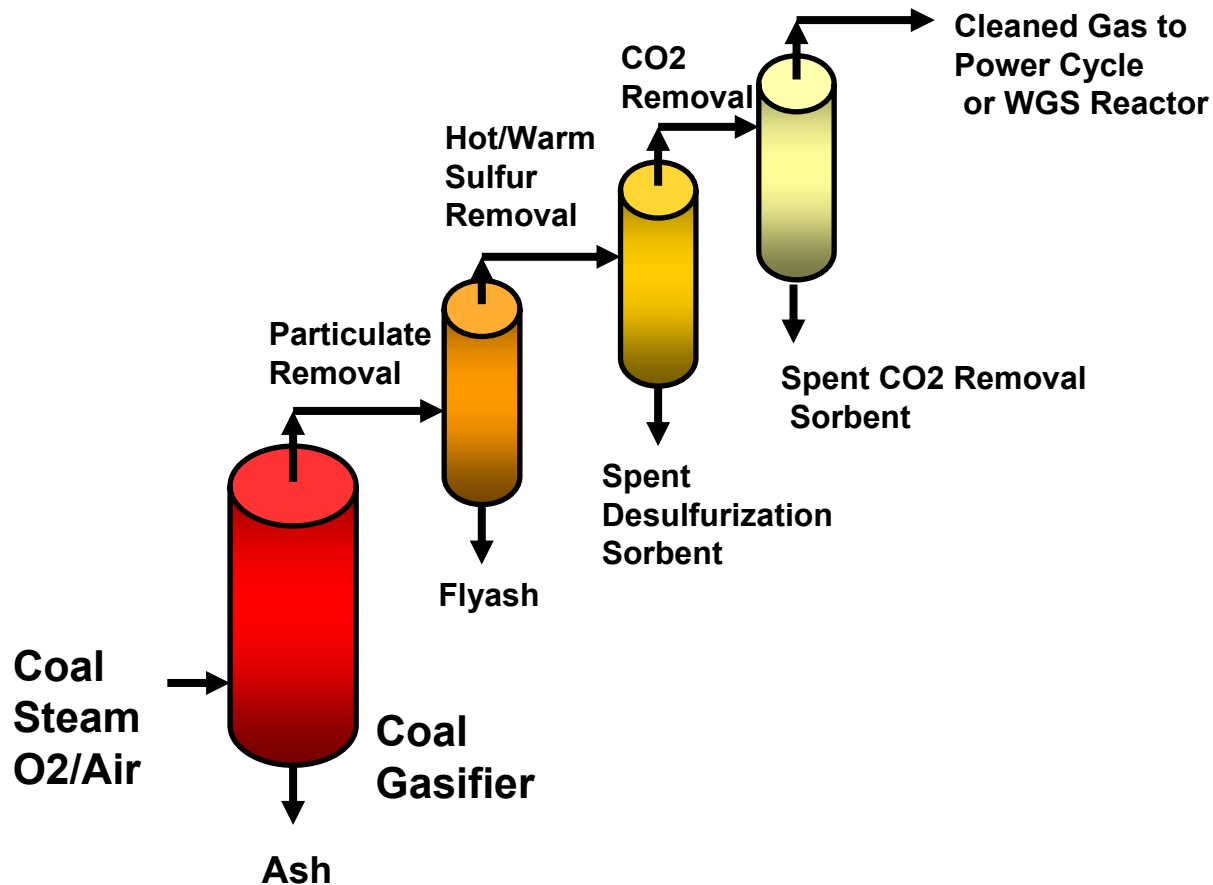
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**IIT**

# Coal Gas Processing w/o CO<sub>2</sub> Removal



# Coal Gas Processing with CO<sub>2</sub> Removal



# Motivation of the Study

## ➤ Advantages

- ❖ Maintaining High Efficiency (Gas Reheat, Steam Loss)
- ❖ Avoiding Capital Intensive Equipment (Heat Exchanger, Condensate Removal System)
- ❖ Co-Production of High Value Products [Superior Fuel, Premium Fuel/Chemicals ( $H_2$ )]
- ❖ Eliminating Corrosive Solvents (Amines)

## ➤ Issues??

- ❖ Process Economics is highly dependent on the Sorbent
- ❖ Desirable Sorbent Characteristics are very Demanding
- ❖ Long Term Durability is Crucial



# Required Sorbent Characteristics

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- **CO<sub>2</sub> absorption (250-450 C)**
- **Simple regeneration**
- **Sulfur Resistant**
- **Economical**



# Chemical Reactions

## Sorption



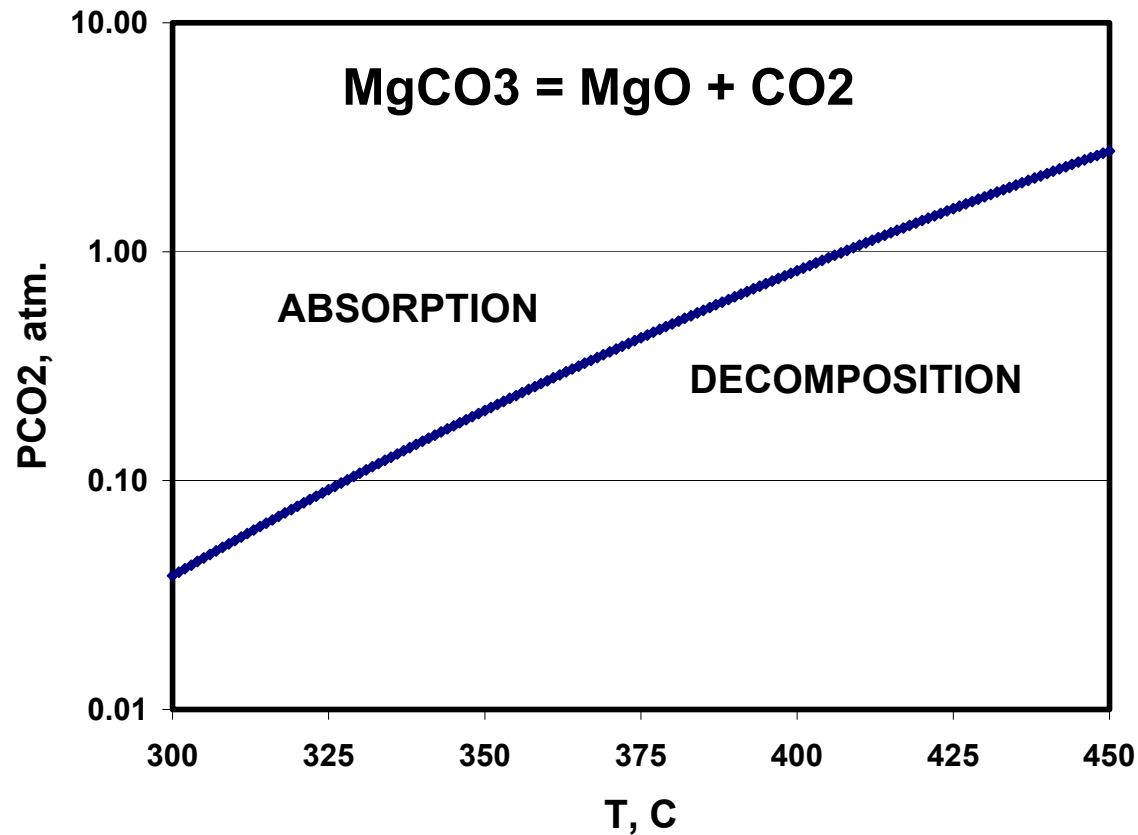
## Regeneration



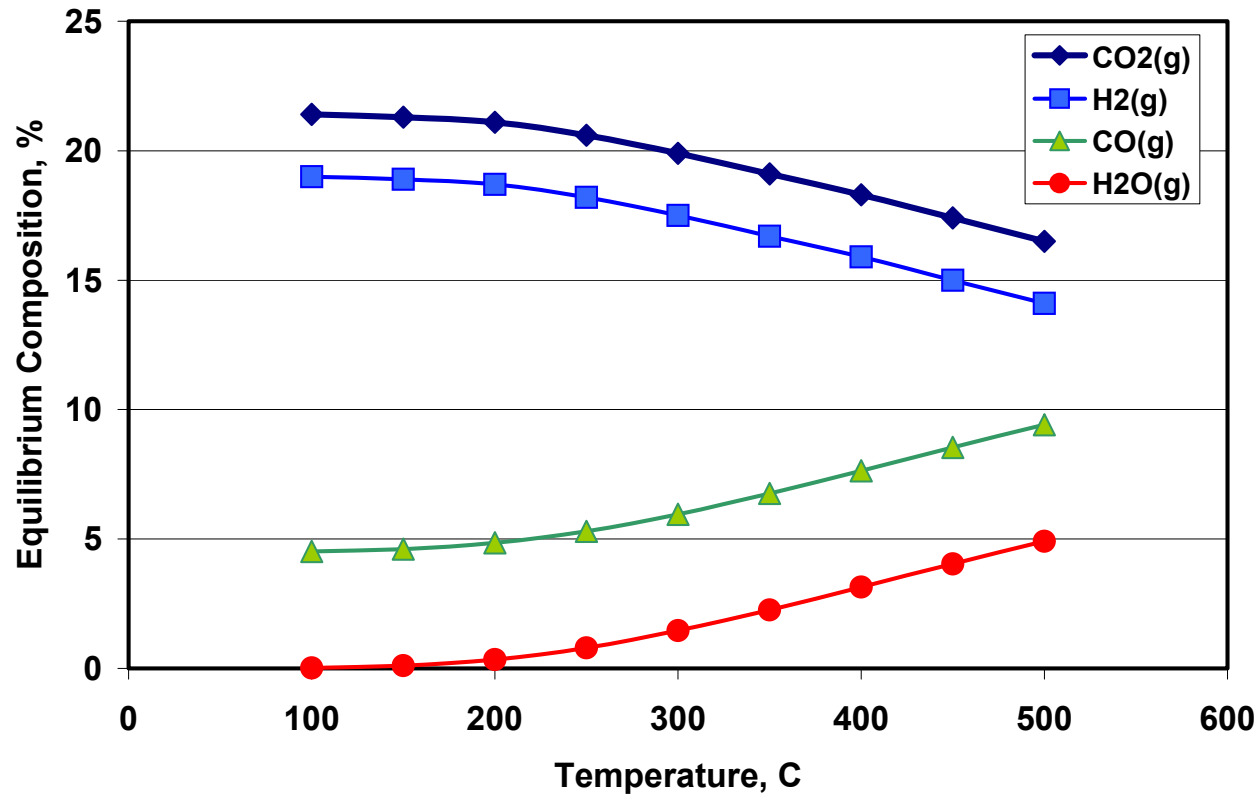
## WGS



# MgO-CO<sub>2</sub> Equilibria

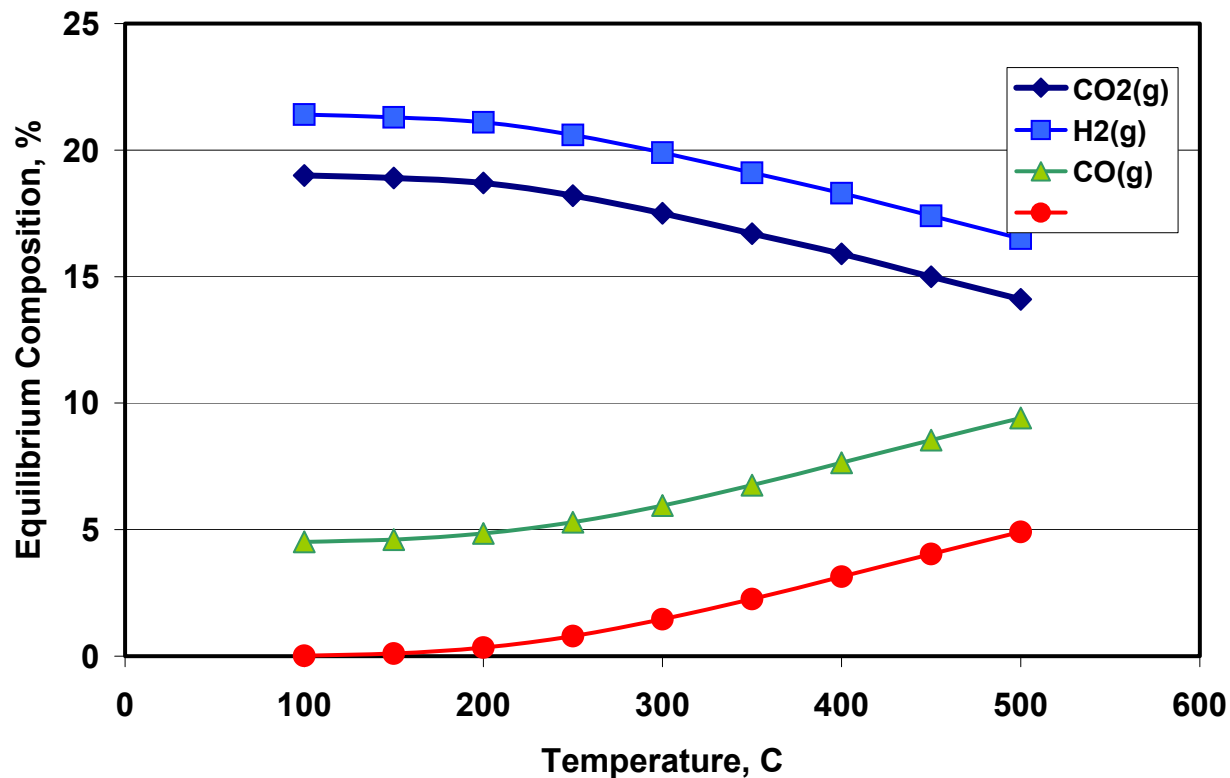


# WGS Equilibria in Coal Gas (Texaco)

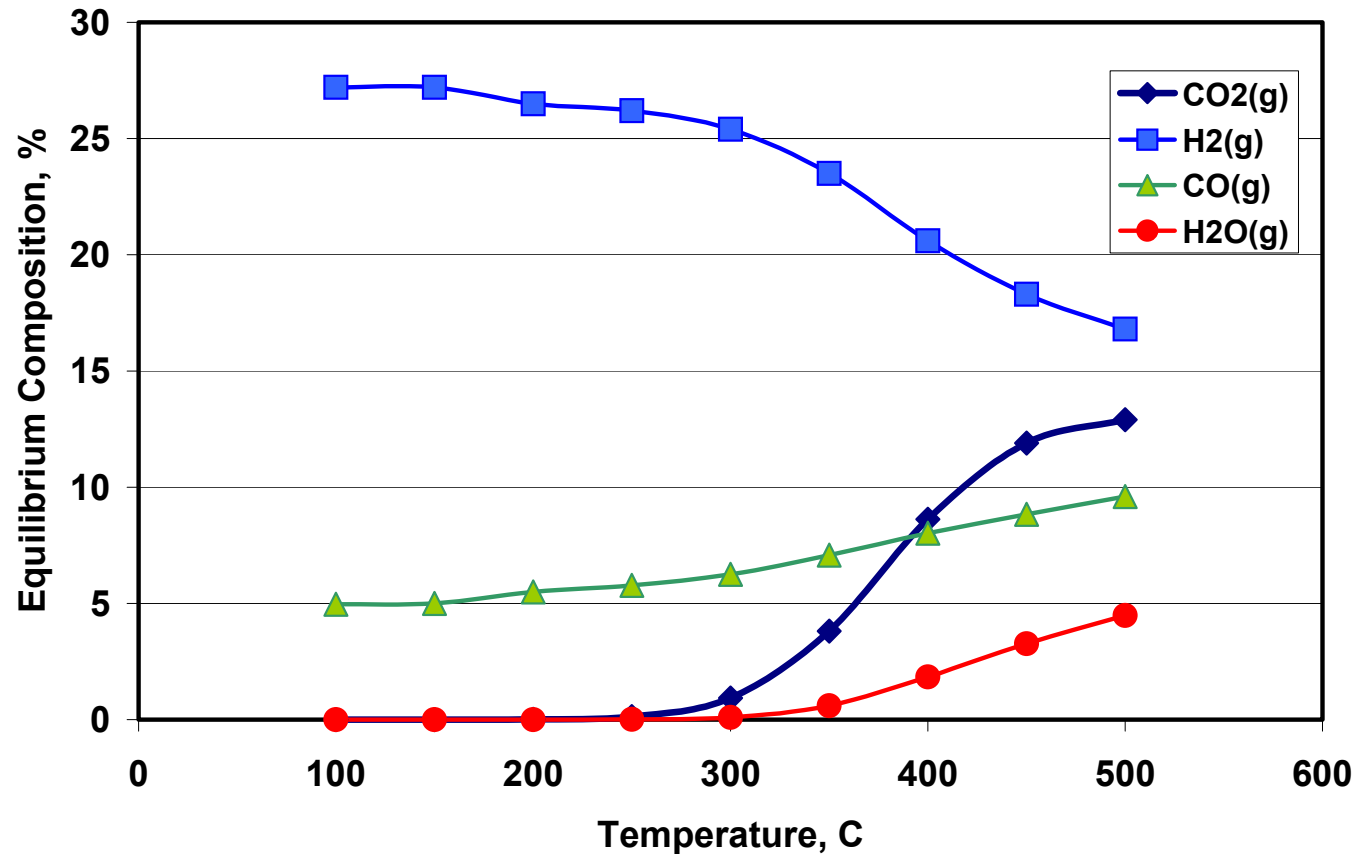




# WGS Equilibria in Coal Gas (Texaco) with Cao-Based Sorbent



# WGS Equilibria in Coal Gas (Texaco) with Mgo-Based Sorbent



# Desired Sorbent Characteristics

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- **High Effective Capacity**
- **High Reactivity**
- **Low Attrition**
- **Long Term Durability (# of Cycles)**
- **Low Cost per Unit CO<sub>2</sub> Removed**



# Objective

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**To develop MgO-based sorbents with chemical and physical characteristics and long term durability that permit cyclic regeneration over many cycles.**



# Sorbent Preparation

Sorbent Type	No.
Total	29
-- Sol-Gel Sorbents	22
-- Modified Dolomite	7
-- Impregnated Sorbents	13
-- Incorporated Sorbents	16
-- Granular Sorbents	17
-- Pellet Sorbents	12
-- Sorbent with additive	17
-- No. of additives	5

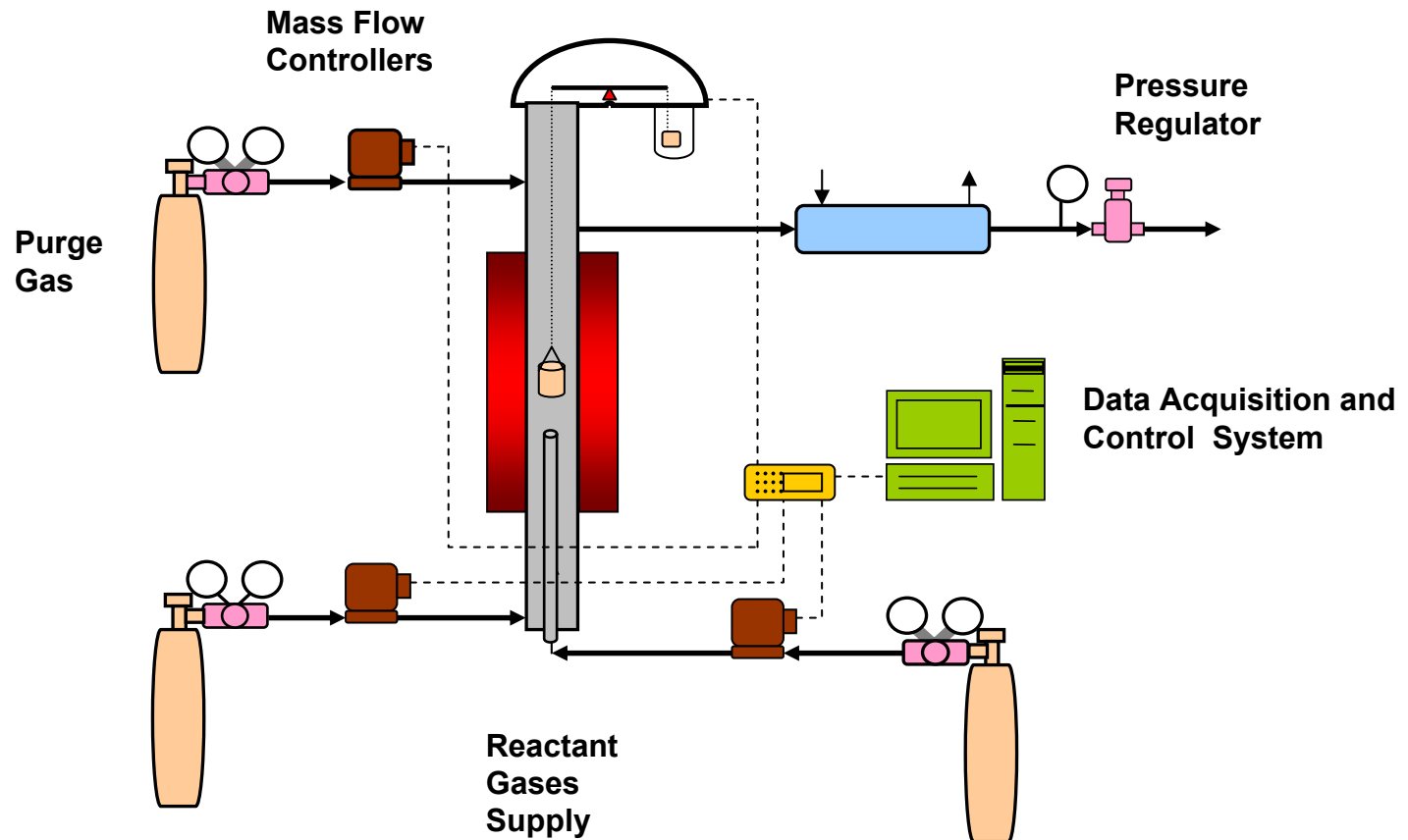


# Sorbent Characteristics

<b>Magnesium Content, %</b>	<b>10-20</b>
<b>Specific Surface Area, m<sup>2</sup>/g</b>	<b>120-280</b>
<b>Additive, %</b>	<b>1- 6</b>
<b>Attrition Index, %</b>	<b>0.04-2</b>



# Schematic Diagram of the High Pressure TGA Reactor



# Sorbents Evaluation

<b>TGA Test</b>	<b>No</b>
<b>Runs</b>	<b>32</b>
<b>Sorbents Tested</b>	<b>14</b>
<b>Individual Cycles</b>	<b>63</b>
<b>Successive Cycles</b>	<b>1-8</b>



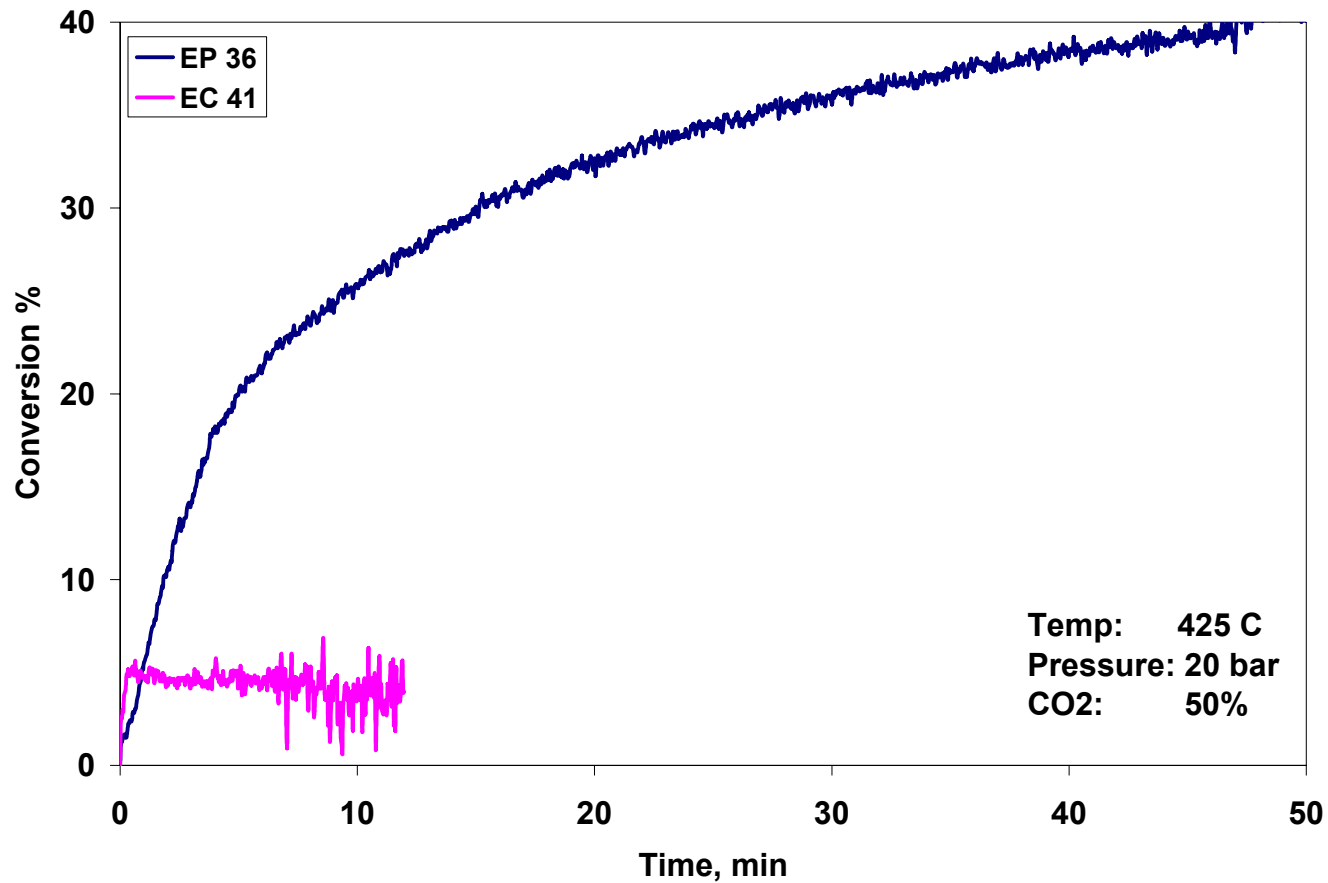


# Operating Condition

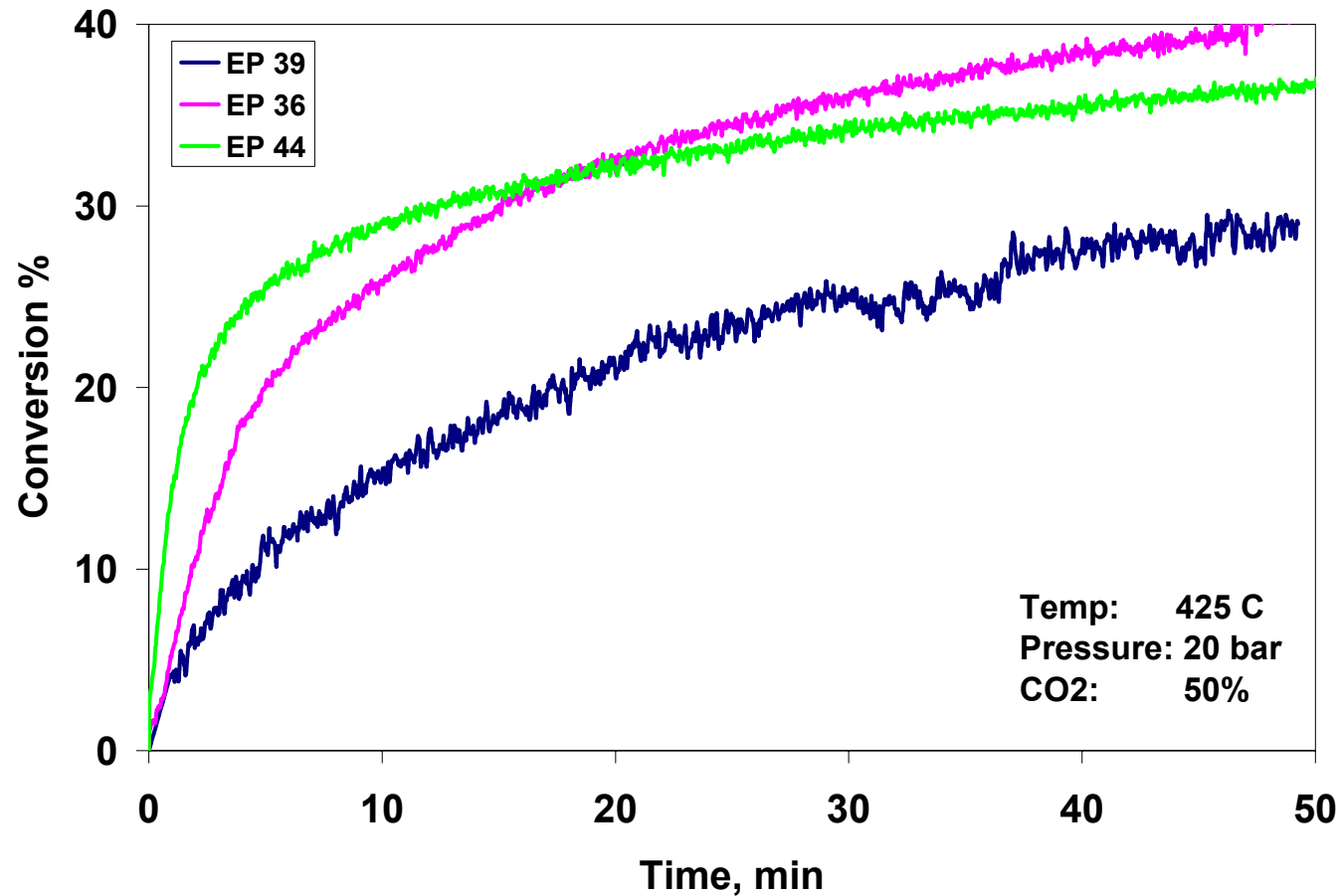
<b>Absorption Temperature, °C</b>	<b>360 - 500</b>
<b>Regeneration Temperature, °C</b>	<b>425 - 600</b>
<b>Pressure, bar</b>	<b>20</b>
<b>CO<sub>2</sub> concentration, %</b>	<b>50</b>
<b>Carrier Gases</b>	<b>He, N<sub>2</sub></b>



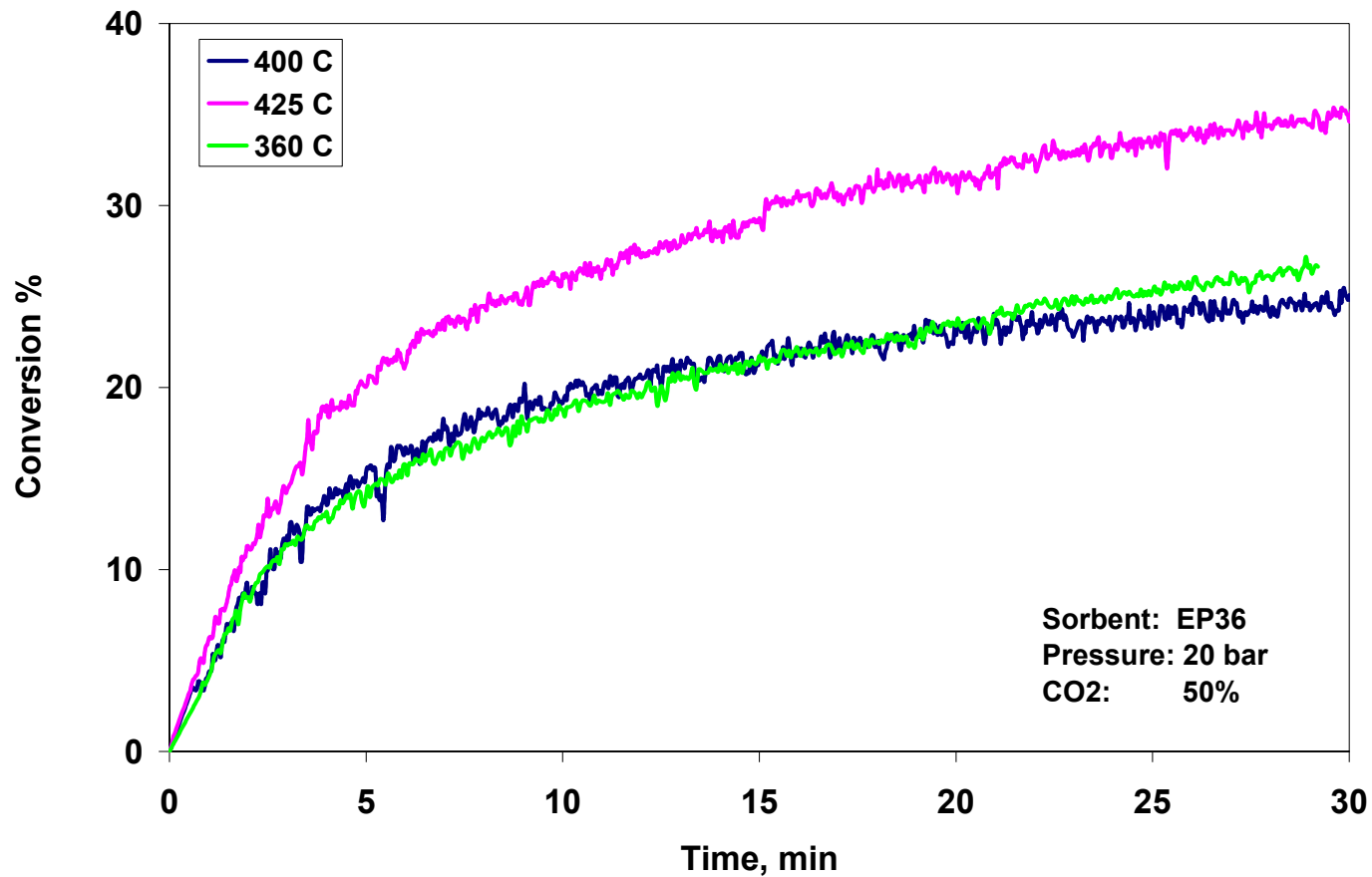
# Comparison of Sorbents



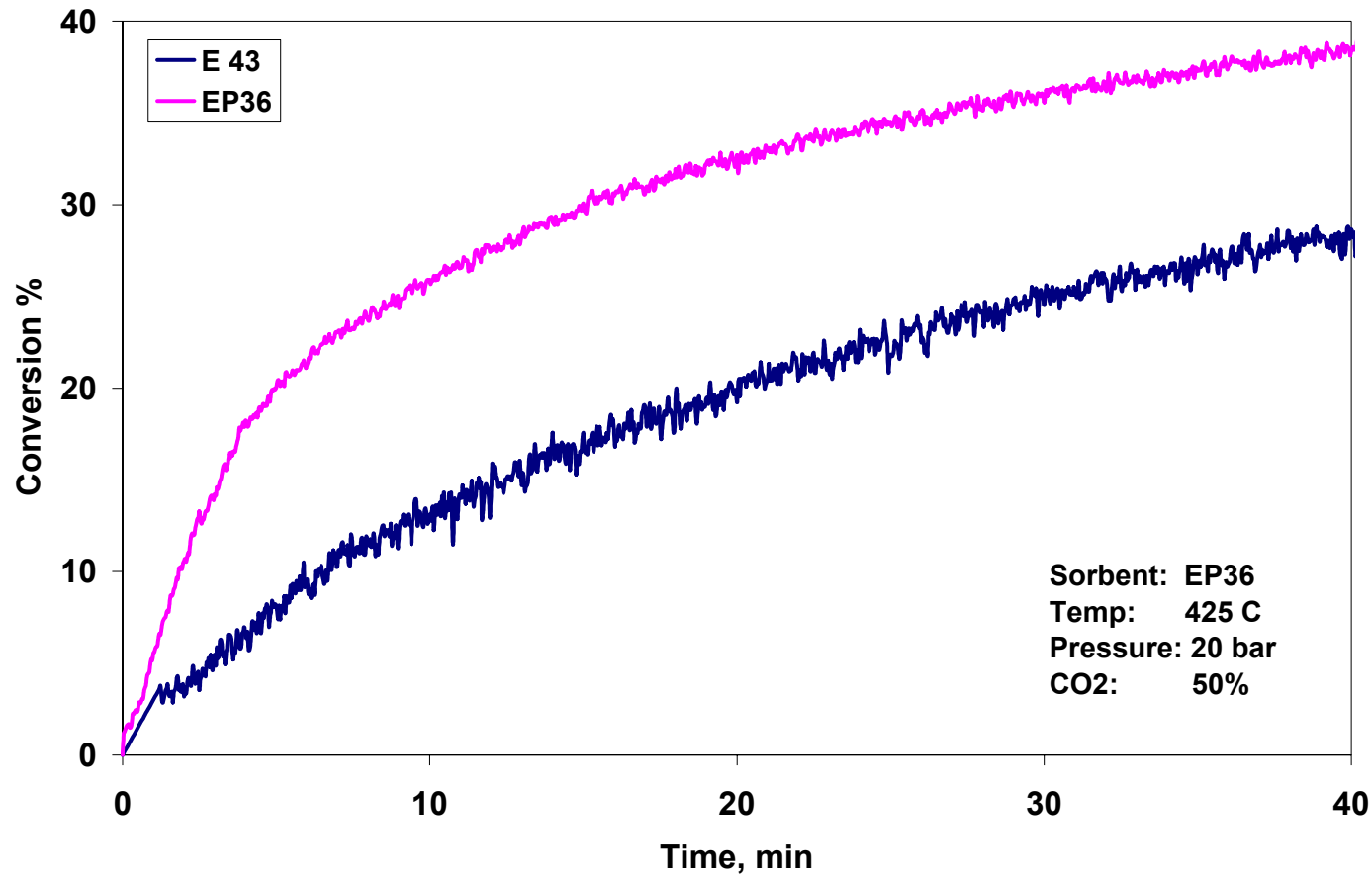
# Effect of Additive Concentration



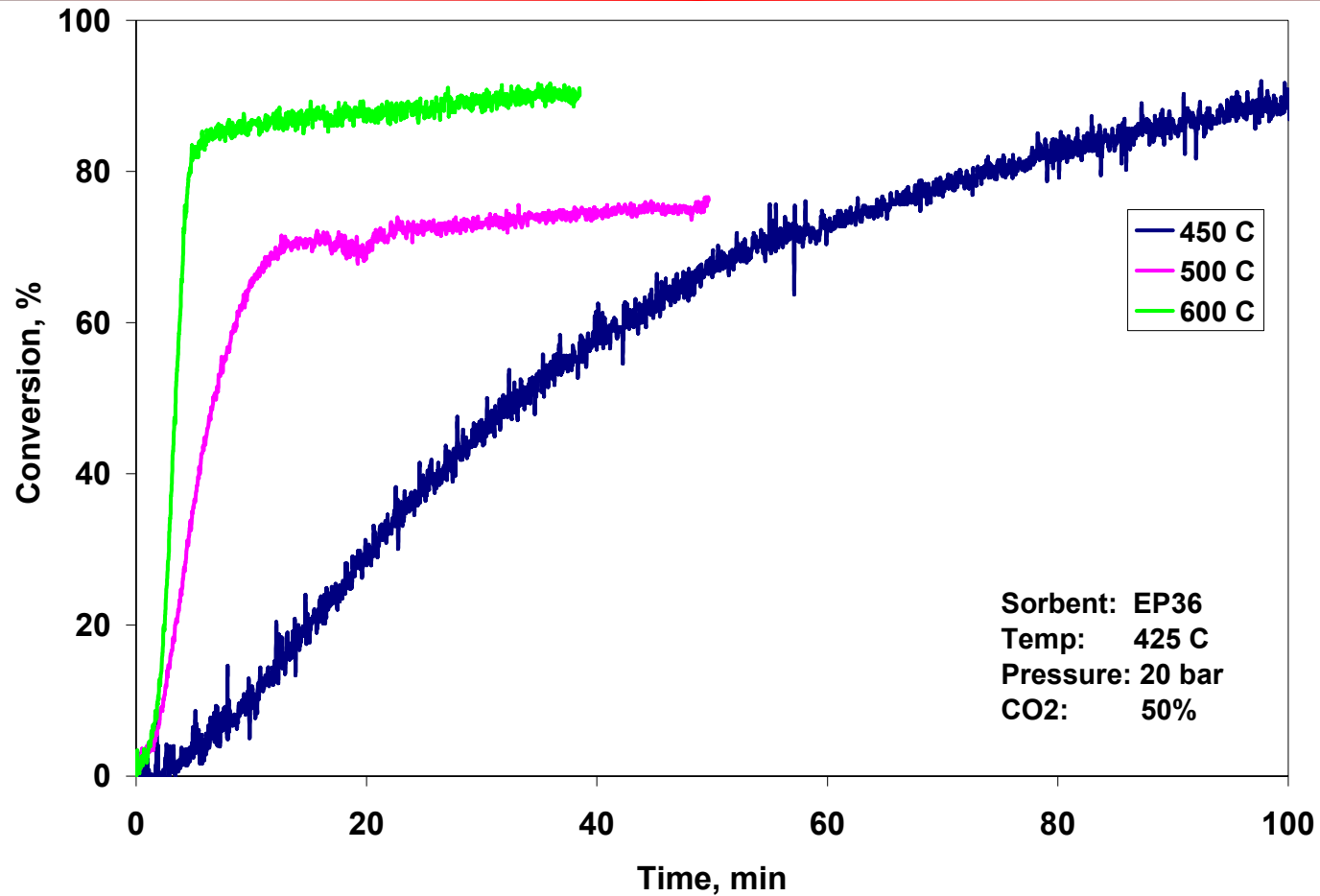
# Effect of Temperature



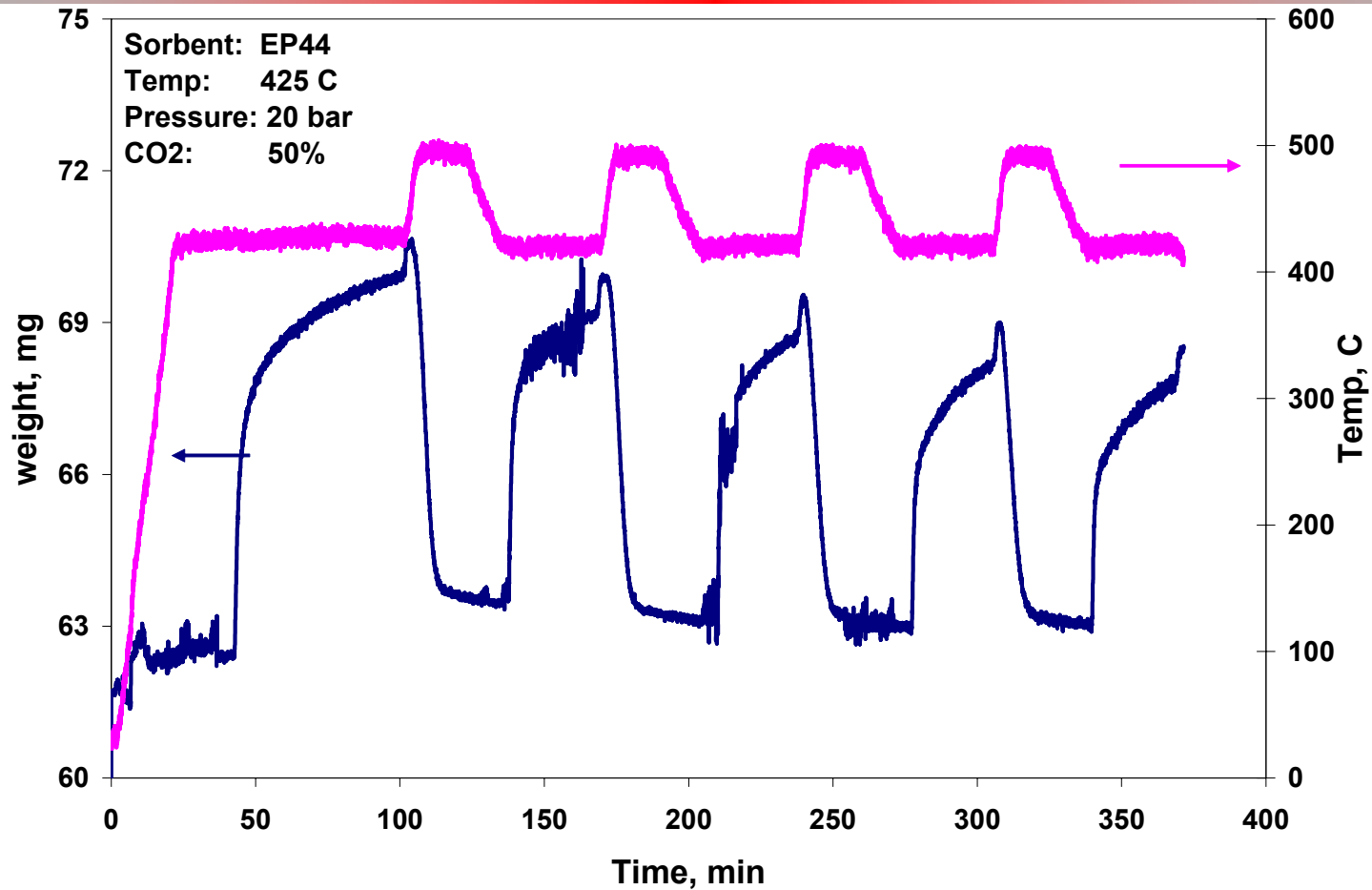
# Effect of Calcining Temperature



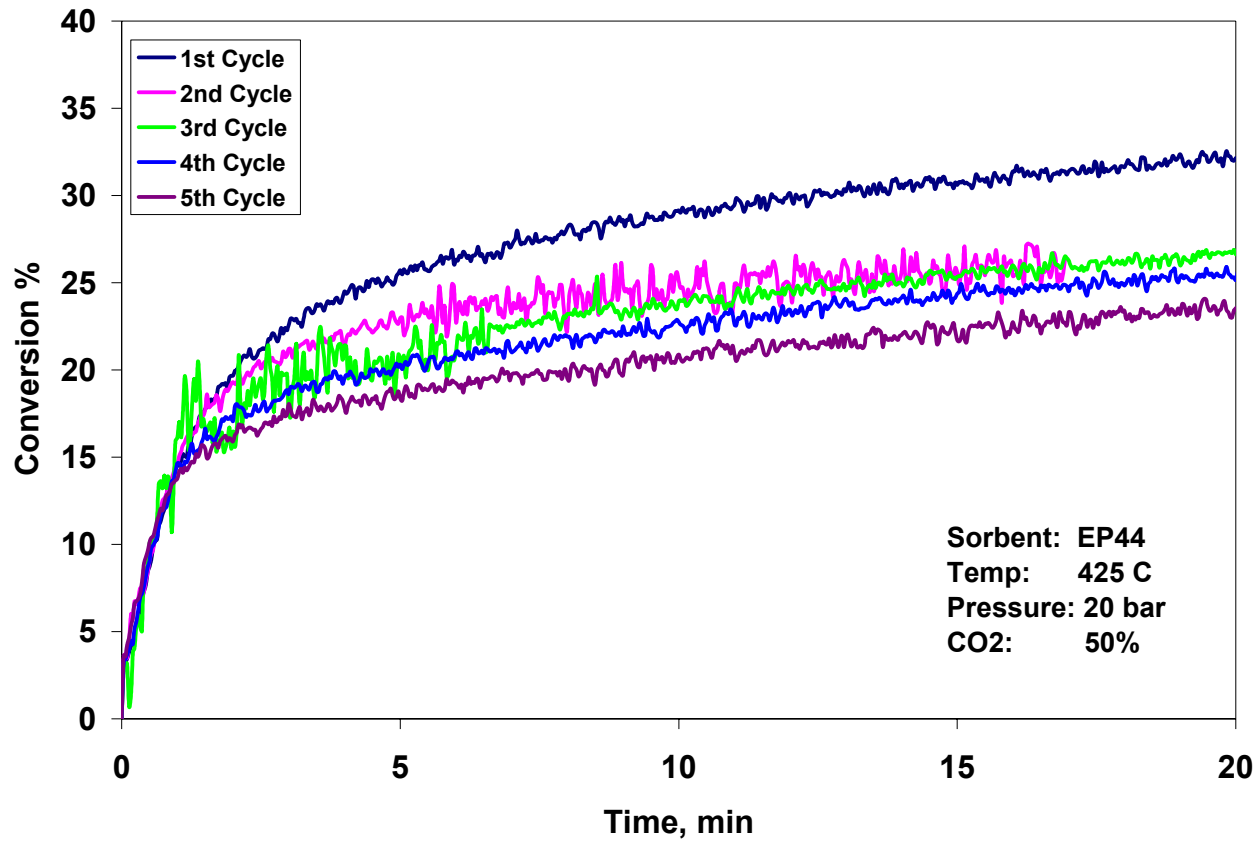
# Effect of Temperature on Regeneration



# Sorbent Regenerability

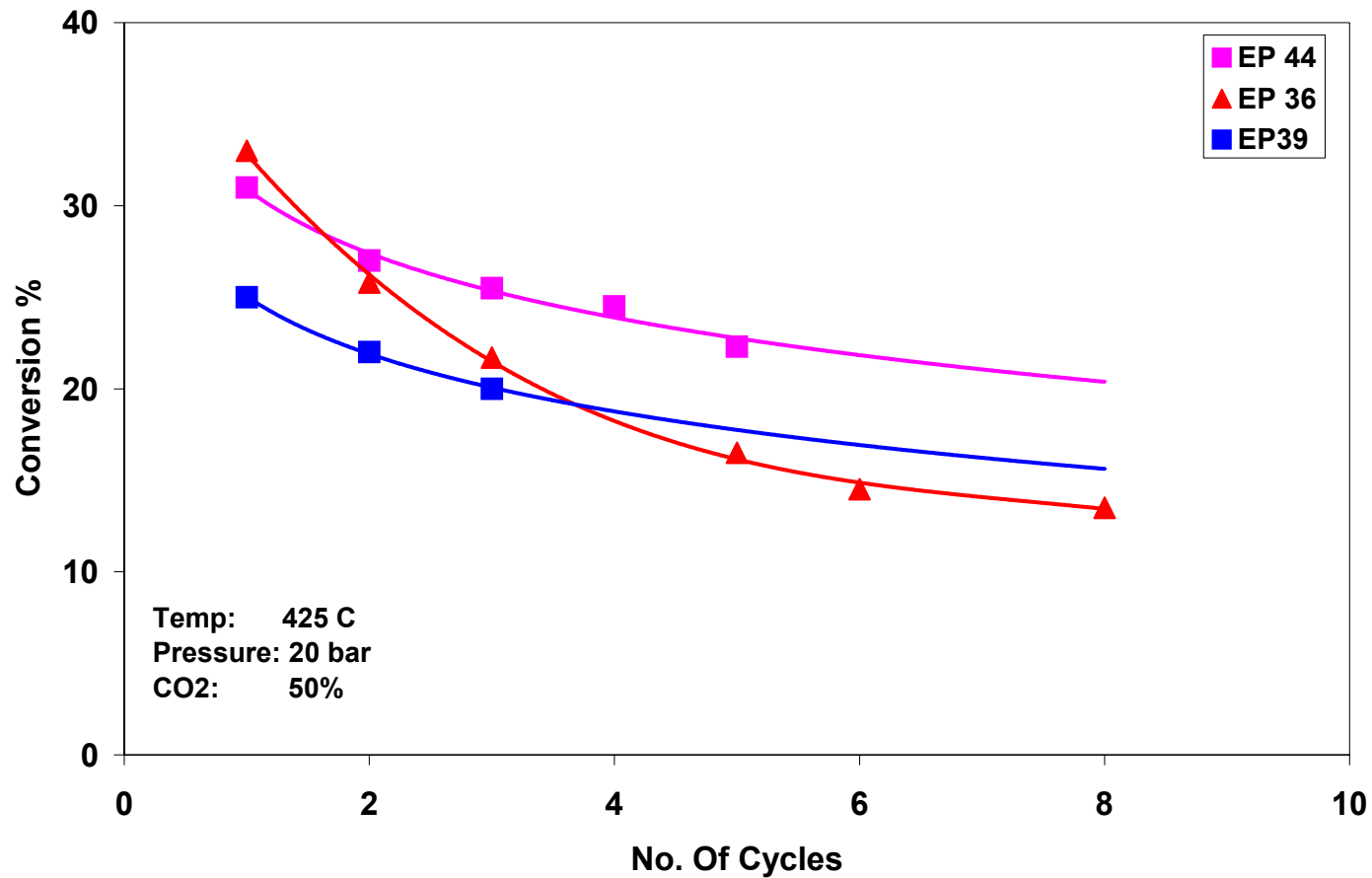


# Effect of cycling

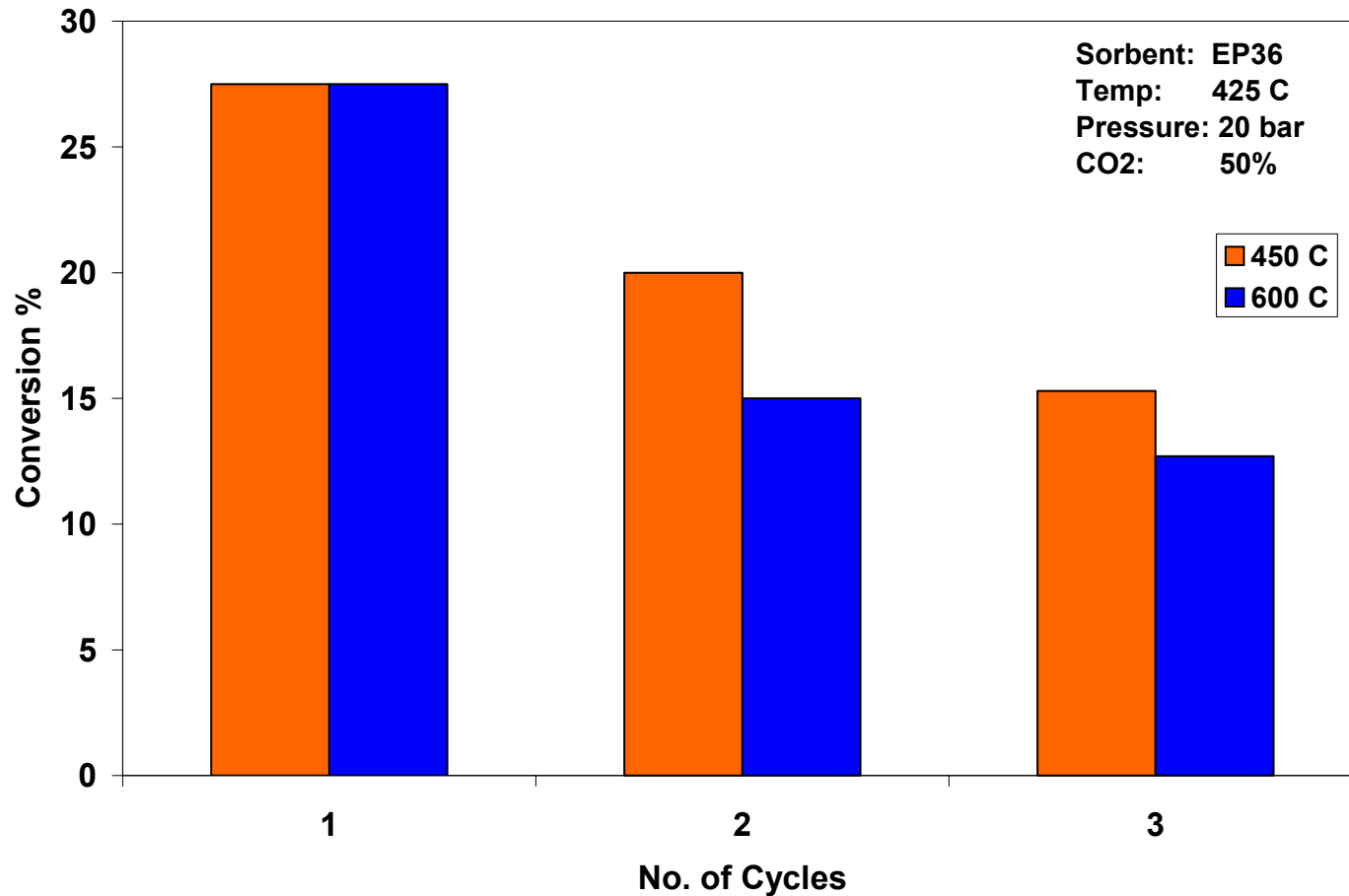




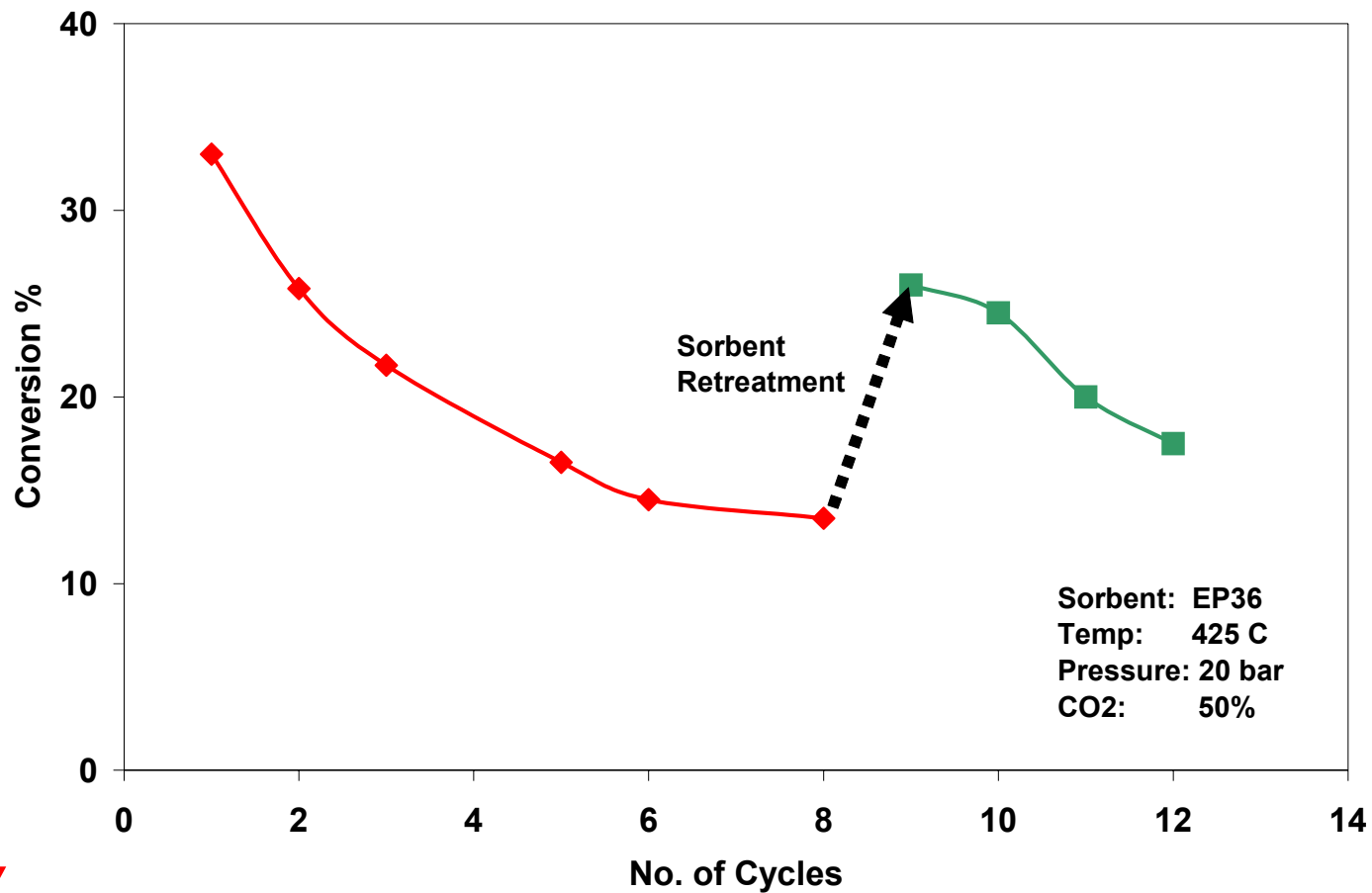
# Effect of Cycling on Sorbents



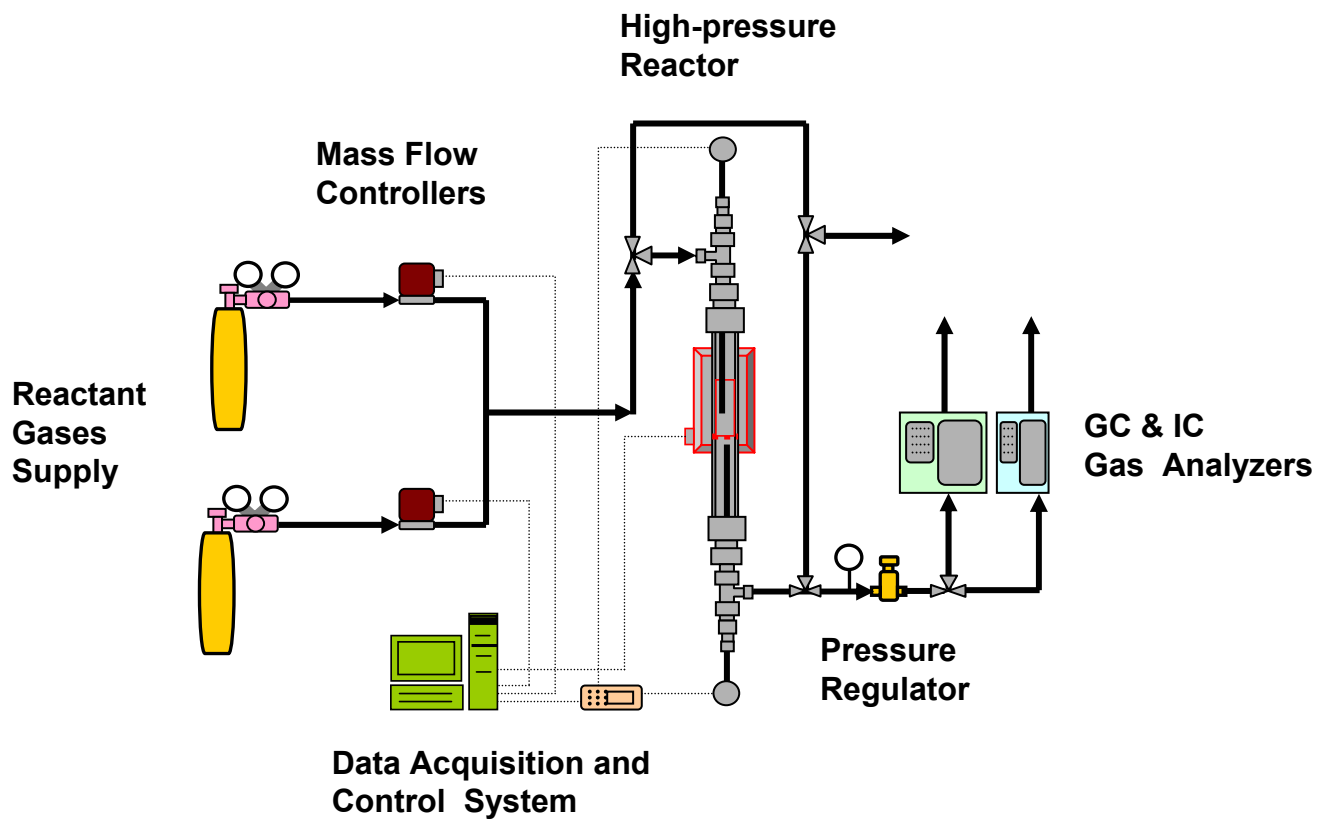
# Effect of Regeneration Temperature



# Sorbent Retreatment



# Schematic Diagram of the High Pressure Fixed-Bed Reactor



# Conclusions

- ▶ Sorbent prepared by sol-gel technique have very low attrition index and low capacity.
- ▶ Sorbents prepared by modification of half-calcined dolomite have very good reactivity, sorption capacity, and attrition index.
- ▶ Dolomite-based sorbents showed good reactivity in the temperature range of 360- 450 C.



## Conclusions (cont..)

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- ▶ **Sorbent reactivity and capacity decreases with cycling, but appear to be approaching a stable level.**
- ▶ **Sorbent reactivity and capacity can be restored to the initial values through sorbent re-treatment.**



# Future Work

- Continuation of sorbent Modification
- Sorbent Evaluation at high Pressure TGA and Fixed Bed
  - ❖ Effect of lower temperature
  - ❖ Extended Durability test (25-Cycle)
  - ❖ Repeated sorbent re-treatment
  - ❖ Effect of simulated coal gas ( $H_2$  production)
- Initial evaluation of simultaneous  $CO_2$  capture and WGS reaction for  $H_2$  Production



# Reproducibility

